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**Investigation into the phase separation phenomenon in the re-entrant ferromagnetic systems, $Nd_{0.5-x}La_xCa_{0.5}MnO_3$ and $Nd_{0.5}Ca_{0.5-x}Sr_xMnO_3$**

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Beamline(s): X7A

**Introduction:** The re-entrant ferromagnetic phenomenon brought about by the change in size or chemical pressure effects was re-investigated on the basis of phase separation phenomenon[1]. The end compositions, $Nd_{0.5}Ca_{0.5}MnO_3$ $Nd_{0.5}Sr_{0.5}MnO_3$[2,3] and $La_{0.5}Ca_{0.5}MnO_3$, are known to be charge-ordered and antiferromagnetic at low temperatures. $Nd_{0.25}La_{0.25}Ca_{0.5}MnO_3$, $Nd_{0.5}Ca_{0.3}Sr_{0.2}MnO_3$ compositions on the other hand exhibit re-entrant ferromagnetic behavior. In $Nd_{0.25}La_{0.25}Ca_{0.5}MnO_3$[4], phase separation is observed over small region in the temperature axis, the phases being the charge-ordered phase and the room temperature orthorhombic phase. Below the ferromagnetic transition, the charge-ordered phase is melted and the sample exists a single orthorhombic phase. We have tried to investigate the possible presence of phase separation in these two series'. We have examined 3 samples in the series $Nd_{0.5-x}La_xCa_{0.5}MnO_3$ (x = 0.15, 0.25, 0.35) and 2 in the series $Nd_{0.5}Ca_{0.5-x}Sr_xMnO_3$.

**Methods and Materials**: We have used the high-resolution synchrotron X-ray diffractions techniques (X7A beam line at NSLS, BNL) as a major tool in following the phase separation behavior in this system. GSAS software suit was used to do Rietveld refinement on these data. The X-ray data was supported by SQUID magnetic measurements and low temperature conductivity measurements.

**Results**: Comparing the X-ray data of the samples prepared in $(Nd_{1-x}La_x)Ca_{0.5}MnO_3$ series with the previously reported data of x = 0.25, we have a better understanding of the phase separation behaviour in this system. The orbital-ordering occurred at ~225K remains intact even at the lowest temperature and the second phase have a smooth variation with the decrease in temperature. The majority phase remain orbital ordered up to 20K. In this case the minority ferromagnetic phase is not strong enough to melt the orbital/charge ordering in the majority phase. Phase separation behaviour is observed in the case of samples in the $Nd_{0.5}Ca_{0.5-x}Sr_xMnO_3$ also. Combining with the SQUID and conductivity data, we have concluded that the amount of ferromagnetic ordering depends on the extend of phase separation observed in these compounds

**Conclusions**: We have concluded that the phase separation, re-entrant ferromagnetism and sample homogeneity in these compounds are closely related. The question about whether the phase separation behaviour is an intrinsic or an extrinsic effect is still under debate.

**References**: Moreo,A., S.Yunoki and E.Dagotto, *Science*, 283 (1999); Woodward, P. M.; Cox, D. E.; Vogt, T.; Rao, C. N. R.; Cheetham, A. K. *Chem. Mater*. 11, 3528, 1999 ; Woodward, P. M.; Vogt, T.; Cox, D. E.; Arulraj, A.; Rao, C. N. R.; Karen, P.; Cheetham, A. K. *Chem. Mater*. 10, 3652 (1998); Arulraj, Anthony; Biswas, Amlan; Raychaudhuri, A. K.; Rao, C. N. R.; Woodward, P. M.; Vogt, T.; Cox, D. E.; Cheetham, A. K, *Phys. Rev. B: Condens. Matter Mater. Phys*. 57, R8115 (1998).